DOCUMENT RESUME

ED 069 757 TM 002 212

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TITLE Introduction to Computer Managed Instruction and the Automated Instructional Management System.
INSTITUTION Wisconsin Univ., Madison. Counseling Center.
PUB DATE Jun 72
NOTE 26p.
JOURNAL CIT Counseling Center Reports, v5 n8 June 1972

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS Academic Performance; Behavioral Objectives; *Computer Assisted Instruction; *Computer Programs; Curriculum; Educational Diagnosis; Educational Objectives; Evaluation; Feedback; *Individualized Instruction; Pretests; Tests
IDENTIFIERS AIMS; Automated Instructional Management Systems; CMI; *Computer Managed Instruction

ABSTRACT

Computer Managed Instruction (CMI) uses the computer to collect and process information to meet an increasing demand for individualized instruction. Learning goals are expressed in terms of behavioral objectives for a given curriculum. Student performance is monitored through computer input and feedback; this allows an accurate and frequent check on a student's progress. A pre-test, diagnosis, prescription, and post-test sequence is used to establish objectives and to evaluate performance. The Automated Instructional Management Systems (AIMS) developed at New York Institute of Technology is a CMI system which emphasizes collection monitoring, student progress, and prescription information. (Author/RS)

Counseling Center Reports

The University of Wisconsin 415 West Gilman Street Madison, Wisconsin 53706

Editor: Richard W. Johnson

Volume 5, Number 8 June, 1972

INTRODUCTION TO COMPUTER MANAGED INSTRUCTION AND THE AUTOMATED INSTRUCTIONAL MANAGEMENT SYSTEM

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Abstract

Computer Managed Instruction (CMI) utilizes the computer as a "tool" for collecting and processing information to meet the increasing demand for individualized instruction. Learning goals are expressed in terms of behavioral objectives for any given curriculum. Student performance is monitored via computer input and feedback which allows an accurate and frequent check of the progress of a particular student. A pre-test, diagnosis, prescription and post-test sequence is used to establish objectives and to evaluate criterion performance. The Automated Instructional Management System (AIMS), developed at New York Institute of Technology, is a CMI system specifically designed to be versatile and independent of course or curriculum. Data collection monitoring, student progress, and prescription information are emphasized.

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INTRODUCTION TO COMPUTER MANAGED INSTRUCTION

AND THE AIMS SYSTEM

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One of the major "accomplishments" of today's institutions of higher learning is the success with which they have alienated their clientele. Depersonalization and decreased effectiveness of instruction have gone hand in hand. Indeed, the practical and financial realities of the education explosion have necessitated large classes, teaching pitched to the average, and less contact with students. Variations in the abilities and needs of students have been subordinated to the very real desire of keeping the costs of education within the reach of all.

The educational revolution in progress today is not limited to the daydreams of a small group of campus radicals. The very titles of recent books indicate an underlying dissatisfaction--Compulsory Mis-Education (Goodman, 1964), Where Colleges Fail (Sanford, 1967), The Academic Revolution (Jencks and Riesman, 1968), Crisis in the Classroom (Silberman, 1970), and Deschooling Society (Illich, 1971). Generally speaking, these develop three basic themes: (1) that instruction must be made more responsive to the individual, (2) that the more traditional administrative frameworks for education, i.e., grades, classes, diplomas, school buildings, etc., are outmoded, and (3) that education must be made more relevant to the social issues of the day.

A tool now exists to take the everexpanding body of human knowledge and fit it more precisely than ever before to the individual in the

fulfillment of his potential, a tool to dealienate and rehumanize, and that tool is the computer. With it the realities of expanding class size and an increasing need for individualized instruction can be confronted. With it information can be gathered at frequent intervals on individual student goals, abilities, needs, and progress, and used to gear instruction to the individual. The computer is the basis of a technology which "clearly points the way to major changes in education that will free the individual, both teacher and student, to interact in more human ways than ever before" (Holtzman, 1970).

THE MOVE TO INDIVIDUALIZATION

The emphasis in education is shifting today from a concern with the group norm toward a concern for the individual including his needs, his capabilities, and his personal preferences. Individualization presupposes several things on the part of the teacher: knowledge of the educational status of his pupils as individuals, organization of the materials of instruction so as to permit flexible assignments and educational alternatives, the ability to monitor and continuously assess the student's performance, and the adoption of a technique of instruction which will, by freeing a large part of the teacher's time, enable him to direct or manage individual work.

Glaser (1969), speaking of education at the university level, recognizes the pressing problem of providing an instructional environment adaptive to individual differences. He presents a model for individualized learning consisting of six components: (1) The goals

of learning are specified in terms of observable student behavior and explicit descriptions or statements of educational outcomes are provided. (2) Diagnosis is made of the initial capabilities with which the learner begins a particular course of instruction. (3) Educational alternatives adapted to the initial profile of the student are presented to him. These might be lectures, readings, tapes, slides, discussion groups, etc. (4) Student performance is monitored and continuously assessed as the student learns. (5) Instruction proceeds as a function of the relationship between measures of student performance, available instructional alternatives, and criteria of competence. (6) As instruction proceeds, data are generated for monitoring and improving the instructional system.

This is not how instruction takes place today. There exist few accurate indicators of class progress and measures of individual student progress are almost non-existent. The small number of professor-student contacts which occur present, at best, an unrealistic view of overall class comprehension. Examination scores, generally the best indicators available, are not very useful in that they usually conclude a section of the course and thus their possible feedback value for the professor in altering his materials or his method is diminished. This untimeliness of available information poses a serious problem. Even if the usual sources of information on class progress were accurate, they typically come too late to correct a deficiency or to capitalize on a strength.

Without accurate and frequent feedback, the teacher has no way of knowing whether his pace is the correct one for his class. Moreover, even if he proceeds at a rate which is neither too slow nor too fast

for the majority, students at the extremes--those experiencing difficulty and those who are unchallenged--may well be participating less than optimally.

CMI--WHAT IS IT?

A solution to the problem is within reach--Computer Managed Instruction (CMI), a system wherein the computer is used as a tool in the management of the information needed by teachers in planning a more effective individualized curriculum. A computer management system has as its objectives the collecting and processing of information on each student and the supplying of this information to the teacher in summarized form such that it is directly applicable to human decision-making. Information in a different form can also be supplied to the student and used by him in choosing his next instructional sequences. The computer can be programmed to suggest decisions to the teacher, based upon analysis of the learning process and of past experience with similar students. The teacher can then decide whether to accept, revise, or reject the recommendations. According to Cooley and Glaser (1969), "the primary function of the computer in a CMI system is to make possible more complicated decision processes than would be possible without the computer, and to do this on a continuous basis. Automation cannot be justified if the computer is used simply to keep records. Clerks tend to be cheaper record keepers than computers. In an individualized system, the teacher continuously needs information and assistance in making instructional decisions."

In contrast with Computer Assisted Instruction (CAI), where the student participates with the computer on a direct basis and the instructional materials are stored in the computer system, CMI is a system whereby the computer and the teacher cooperate to administer and guide the instructional process. Instructional materials are not stored in the computer system. The computer becomes not a "teaching machine" but an information system which records the student's learning, academic history, lists his program of studies, scores the tests and exams, and furnishes this information to the teacher. It is concerned with the non-instructional or managerial aspects of the educational program.

The four major functions performed by a computer in existing instructional management systems are test scoring, diagnosis, prescription, and reporting. Generally, these are incorporated into the curriculum as follows: At the beginning of each unit of instruction, a pre-test is taken by a pupil to determine his initial status relative to an objective. The student's answer sheet is processed by an optical scanner and scored by means of a computer program. The test may be simultaneously scored for several main objectives and numerous sub-objectives. On the basis of the pre-test results, the pupil is assigned to specific learning tasks. The making of such assignments can be fully automated by computer programs which relate test scores to learning tasks. If full automation is not desired, the computer can generate the test results in the form of a printed report to the teacher. The report then becomes one of several information sources used by the teacher to

prescribe learning tasks for a student. At various points, the student may take diagnostic or progress tests covering specific objectives. These tasks again are computer processed and the reports used to ascertain whether the pupil is progressing satisfactorily. When a pupil has completed the assigned tasks, he takes a post-test covering the unit of instruction. These are criterion referenced tests and the pupil is scored on one or more objectives. If he obtains a score of 85% or greater on a given objective, he is considered to have achieved that objective. If a student fails to reach criterion performance, he can then be assigned remedial material. After the administration of each test, the teacher receives several printed reports. One report lists each pupil, the unit of instruction, the objective, and the percentiles achieved for each objective. Using this report, the teacher can study the pattern of accomplishment of each pupil and identify pupils who require additional attention. A second report is structured by curricular objectives and shows the proportion of pupils in a group achieving criterion performance on each of the several objectives. On the basis of this report, the teacher can observe common strengths and weaknesses of the group and adjust the instruction to fit the situation. The basic pattern of pre-test, diagnosis, prescription, and post-test is repeated for each unit of instruction.

SEVERAL CMI SYSTEMS

IMS

One of the interesting aspects of CMI is that a number of research groups across the country conceptualized their systems nearly simulta-

neously. As a result, it is difficult to credit any one group with the basic idea, but the first operational system was developed at Systems Development Corporation for the Southwest Regional Educational Laboratory at Los Angeles and called IMS (Instructional Management System). The system was implemented initially in the first grade reading program of several schools. The IMS was designed to help the teacher monitor the progress of her pupils and make decisions on the pace of instruction, the grouping of children, the sequence of lessons, and the individualization of instruction, by providing information almost daily about each child's achievement and by suggesting specific activities to help the pupil when he had not learned what was presented in a particular lesson.

The class was divided into several reading groups that received first grade reading instruction based upon a state adopted reading series. Added to this situation was a file of self-administered tests based on the reading series, a file of self-administered pencil and paper exercises used for follow-up work, and a "listening post" where pupils could listen to audio tapes. Upon completion of a typical lesson, the pupils seated at the "listening post" take self-administered tests by following instructions received via their headsets. After class, the answer sheets are taken by courier to the SDC computer facility where they are optically scanned and the responses input to a large computer that processes the test papers. The reports generated by the computer are then available to the teacher the next morning before class for use in planning. The basic report for a particular test contains information related to the specific objectives of that test and how well each pupil performed on the test. When the group score is below the criterion level of 85%, the computer program prescribes a number of remedial

activities for the teacher to consider. These activities are specified by a number which locates a folder in the follow-up material file. In addition to the group information, this report also lists each pupil, his score on the test, the number of tests taken, and the pupil's cumulative average score. At the end of each week, a summary report is produced listing the score made by each pupil on all tests taken to date and his ranking within his reading group. Upon request, the teacher can obtain a report for a given pupil which provides a listing of pupil performance on the general objectives. In addition, a teletype terminal is available in the school for the teacher to use as an inquiry device. By means of this teletype, the teacher can cause the computer to search the data base and report information of interest to him. The flexibility of the data management computer program allows researchers to easily redesign the reports and to add or delete information as new needs arise. The IMS development is a balance between what one would like to do and what can be done in the conventional classroom.

IPI/MIS

Another CMI system, in operation at the Pittsburgh Learning Research and Development Center, is an outgrowth of the individually prescribed instruction (IPI) project and is called the IPI/Management and Information System (IPI/MIS). They began by individualizing the elementary school curriculum with a manual system of test scoring, diagnosing results, prescribing instructional tasks, and record keeping, and later automated these tasks. The computer configuration used consisted of a medium-

sized computer, a large desk storage device, a remote batch input/output station in the school, and three typewriter-style remote inquiry stations in the Learning Research and Development Center. The remote input/output station in the school is used to print three basic types of reports: first, a unit summary for a particular student containing test scores for the pre-test and curriculum embedded tests corresponding to a given instructional unit. The prescription suggested by the computer after each testing is also listed. The teacher uses this report to trace the activities of a pupil within a unit and ascertain how well he performed on the unit. Secondly, a pupil listing is generated, by home room, showing for each pupil the skill, the unit of instruction, and the number of days spent on the unit. Thirdly is an instructional report listing the names of the pupils who are working on a unit and the specific objectives they are currently attempting to master. Again, this report is useful for informing the teacher as to the status of the pupils, each of whom may be engaged in a different task.

PLAN

A project titled "Program for Learning in Accordance with Needs," or PLAN was developed by the American Institutes for Research and Westinghouse Learning Corporation. Although the actual implementation of PLAN follows that of other CMI systems, emphasis is placed upon long term educational goals as they relate to career planning and educationally relevant decision making. Conceptually, PLAN consists of five components:

(1) A comprehensive set of educational objectives which are successively fractioned until the smallest sub-division of the objective requires about two hours of student study time. Approximately five of these smaller objectives are grouped into a module, and the modules are pooled to form an instructional unit of approximately two weeks duration.

(2) Teaching-learning units relating to each objective which provide alternative means for the pupil to use in achieving the objective. At the present time, these units consist of available conventional instructional materials and procedures.

(3) Evaluation procedures involving the use of criterion referenced tests related to the objective within the units and to the long term educational goals. Certain goals are measured via instruments other than multiple choice tests.

(4) Guidance and individual planning procedures designed to aid the pupils in planning their educational development.

(5) The final component consists of a medium sized computer with input/output terminals in the participating schools. The stated function of the computer is to perform clerical and statistical activities of a teacher support nature--scoring tests, maintaining files on the experiences and progress of each student, keeping records on the results achieved by the pupils on the teaching-learning units and on the guidance and planning procedures. The dominant features of project PLAN are the large number of classrooms involved and reliance upon locally available instructional procedures and materials.

TIPS

The concepts underlying computer managed instruction were independently derived by Professor A. C. Kelley in the context of an introductory economics course at the University of Wisconsin. Although the Teaching Information Processing System (TIPS) was developed in isolation, it follows the general model very closely and contains all the basic features of other systems. The TIPS project was embedded within a conventional university level economics course where a professor presented the lectures and teaching assistants conducted small group sessions. Approximately six to ten times per semester all 200 students in the course were administered 10 to 15 item instruments structured according to the objectives of the course and the economic concepts to be attained. The students were assured that these instruments were surveys, not quizzes, and that their purpose was to help them, not to grade them. The multiple choice answer sheets were optically scanned and the punch cards produced were used as input to the TIPS computer programs. These programs scored the instruments, performed the diagnosis and prescription functions, and generated three different reports: a student report, a teaching assistant report, and a professor report. The student report contains a listing of the item choices made by the student and the correct response, his score on the survey, a statement about his level of achievement, and a series of prescribed activities. In sharp contrast to other systems, the prescriptions generated by TIPS are in the form of paragraphs rather than the usual cryptic lesson numbers, and describe what the student is to do, whether it is optional or required, and the date it is due. The prescriptions

vary from the usual homework assignment to attendance at lectures given by instructors in other economics courses. In some cases, the student is referred to his section leader for help in the small group setting. The teaching assistant report identifies the section leader, the survey taken, lists each student's name, and the assignments are described by a short paragraph. Special messages for the section leader name pupils recommended for special help or may alert the section leader to lectures of interest on campus. In addition, an item analysis of each item on the survey is given and sub-scores on the embedded concepts are reported. The professor report summarizes the materials in the student and teaching assistant reports. The mechanisms of the TIPS approach are such that they could easily be applied to other college level courses.

CMS

Another CMI system is the individualized mathematics curriculum project (IMCP) under development since 1964 at the University of Wisconsin which has as its goal teaching children how to plan their own learning objectives in mathematics and how to become increasingly responsible for the organization of available human and material resources necessary to attain these objectives. The computer based system developed is essentially an inquiry system and is called the Computer Managed System (CMS). The CMS project differs from other CMI systems in the areas of diagnosis and prescription. Its diagnostic capabilities are limited to listing pupils according to the units they have mastered or attempted and not mastered. CMS does not generate specific prescriptions

but simply lists all of the units for which a pupil has completed the prerequisites. The actual prescription is left up to the teacher and the pupil, with the pupil having considerable responsibility for making instructionally related decisions.

INDICOM and DRIFT

The INDICOM Project is a developmental program at the Waterford Township School District in Pontiac, Michigan. It employs CMI in the business education curriculum. And finally, DRIFT is a CMI system being used in the Multnomah County Intermediate Education District of Portland, Oregon. A diagnostic test of 85 questions is administered as a pre-test (and post-test) to the sixth grade mathematics program. A comprehensive analysis of wrong response patterns causes the selection of significant diagnostic statements from 200 available. The program has been successfully used for grades 5-9. Prescriptive statements are being added.

It can be seen from the descriptions of these few specific CMI systems that all follow the same basic model. They differ in the original impetus for developing such a system and somewhat in the level of implementation, but the underlying pattern of test scoring, diagnosis, prescription, and reporting is embedded in all of the existing systems. In addition, these systems are based upon a curricular approach in which educational objectives are defined in considerable detail. These objectives then serve as the basis for the design of

instructional procedures, materials, measuring instruments and other aspects of the curriculum. Achieving these objectives requires that instructional materials related to objectives be available to each pupil. The majority of CMI systems employ conventional instructional materials such as textbooks, workbooks, etc., avoiding the extremely high cost of design, development and production of materials suitable for specific instructional objectives. Because the CMI approach can be initiated in the conventional classroom employing conventional materials and instructional procedures, it can be introduced as a tool to assist the teacher within a non-threatening context and the system's capabilities can grow as the teacher is willing to use its additional potential.

EFFECT ON THE ROLE OF THE TEACHER

CMI and teachers can effectively supplement each other. Those things which a teacher can best do, he should continue to do, and those things a computer is particularly suited for, it should do. "The teacher is generally better able to introduce and discuss new concepts, explain subtle points, and respond to student questions. The teacher is far more capable of carrying on a two-way conversation with a student and evaluating the meaning of what has been said. However, it is questionable whether a teacher has sufficient time to analyze the progress of each student on a daily basis, and to continuously individualize the instructional materials and assignments" (Johnson, 1971).

The computer program can embody the best available professional judgment regarding diagnosis and prescription in subject matter areas,

thus providing the teacher with a highly competent assistant to make routine instructional decisions. These are tasks which a teacher can do well for a few pupils but inadequately for a large number. The teacher would monitor pupil performance, ascertain short and long term trends, use this information to understand a given pupil as an individual and supplement this data with uniquely human traits such as understanding, motivation, etc., which are a vital but intangible part of the educational process. The teacher can then develop the management techniques and clinical judgment underlying the successful operation of an individualized program of instruction. The teacher would use the computer as a vehicle for obtaining the timely, accurate, and relevant information needed to fulfill the role of an educational manager.

AIMS

The CMI system developed by the Advanced Systems Laboratory of the New York Institute of Technology was designed to create just such a role for the teacher. It is an impressive production called AIMS (Automated Instructional Management System) and, as described in Helen Lekan's Index to Computer-Assisted Instruction (1971) is "a system for directing a student or a group of students through any course designed around behavioral objectives. Outputs are reports giving the performance information that is directly relevant to the role of the student or instructor or course designer or any combination of these. The system is specifically designed to be independent of the course or curriculum, subject area or level so that it can be utilized with any course material designed around behavioral objectives." AIMS was designed to collect data,

monitor student progress, provide prescriptive information, and diagnose student difficulties. The system was generated to be as versatile as possible without prohibitive input/output requirements, and as course-content free as possible with a maximum emphasis on managed instruction.

The MINI-AIMS, a version of AIMS which generates fewer reports than the entire system is capable of, will provide several kinds of educational services: attendance taking, test marking, performance report generation, and educational assessment report generation. The package is to consist of both on-line terminal programs, written in CALL 360 OS/PL1, and batch-processing programs, written in OS/PL1. In general, the terminal services include attendance taking and test scoring, while the batch services include the generation of the various performance and statistical reports.

Terminal Services:

For attendance taking, a daily attendance card will be input at the terminal for each class period. Each student will have been assigned an "attendance number" corresponding to an attendance card column, and absences will be penciled in appropriate columns. In addition, a voluntary attendance card will be input for "voluntary" attendees at that class period.

For quizzes, a quiz card including the course unit, student, and (right or wrong) answers will be input for each quiz taken by the student.

Unit tests will be graded at the terminal. A unit test card will be input, and the student's name, grade, incorrect answers, and prescriptions will be printed at the terminal. Diagnostic tests are

treated in the same manner as unit tests, except that no grade is printed. The diagnostic or unit test or student directory files may be altered by inputting the appropriate change card. Confirmation of student unit and course grade, indication of unit and course completion, and indication of the next unit the student will be taking will be input via the terminal.

Batch Services:

Batch services include such Student Reports as:

(1) Unit Reports which contain a student's performance record in a completed unit (that is, grade, rate, number of objectives achieved), how far and how well he has progressed in the course and in the school year, and when he can expect to complete the current course at his achievement rate.

(2) Course Reports which indicate a student's performance in a completed course.

(3) Final Reports on Student Achievement for the Year which indicate a student's achievement and performance for the entire year.

(4) Unit-to-Date Reports which indicate a student's performance in a unit "so far."

(5) Course-to-Date Reports which indicate a student's performance in a course "so far."

General Student Assessment Reports which will be generated include "Hustlers" and "Laggards" Reports, indicating students who are achieving (i.e., completing objectives) rapidly or slowly. It will generate Rate Reports which compare the actual rate of achievement with the expected (target) rate of achievement for each student, suggesting how well the student is doing with respect to his own goals.

It will also generate Monthly Course Completions which list students who have completed courses (indicating course and grade) since the last such report, and Quarterly Reports which indicate (a) how well and how much each student has done, (b) the performance norms for all students, and (c) the performance norms for all students within each course.

Among General Student Information Reports will be Cluster Reports indicating the students who have completed a given objective within the past five school days, Student Distribution Reports indicating (1) by learning center, the number of students active in each unit, and (2) regardless of learning center, the number of students active in each unit, Unit Quartiles which indicate the "current" high, middle, and low (75th, 50th, and 25th percentile) rate and grade student performance figures for all students in each unit, Course Quartiles indicating the "current" high, middle, and low rate and grade performance figures for all students in each course, and finally, Year Quartiles indicating the "current" high, middle, and low rate and grade performance figures for all students since the beginning of the school year.

Among Educational Assessment Reports generated will be a Rates Summary Report, indicating (1) for each teacher, the number of students whose actual rate of achievement exceeds their target rate, the number whose actual rate of achievement is less than their target rate, and the overall ratio of actual to target rate for all students of that teacher, and (2) the overall ratio of actual to target rate for all students; Quiz Analysis Reports containing statistics (percent successes, mean scores, standard deviation, etc.) for each quiz (and all quizzes) of a given objective; Quiz Analysis Flag Reports containing a list of

all objectives for which the Cycle 1 student percentage of successes is outside given boundaries; Source Analysis Reports containing statistics for each quiz (and all quizzes) used in preparation for the quiz; Source Analysis Flag Reports containing a list of sources (within each objective) for which the quiz Cycle 1 percentage of success is outside given boundaries; Unit Test Analysis Reports containing statistics for each test (and all tests) of a given unit; Unit Test Analysis Flag Reports containing a list of all unit tests for which the Cycle 1 mean score is outside given boundaries; Diagnostic Test Analysis Reports containing statistics (percentages of success and associated objective numbers) for each segment of a diagnostic test; and finally, a Suspicious Event Report will be generated when the program determines that input errors may have been made.

The potential of MINI-AIMS in monitoring and assessing student performance is almost unlimited. Yet, in the process of demonstrating the feasibility of computer managed instruction it has become apparent that a wide range of problems exist which are intrinsic to individualizing instruction. These problems exist both in CMI systems that are designed to assist the teacher and in CAI systems that are designed to be a means of instruction. The majority of these problems arise in the areas of diagnosis and prescription, as individualization essentially depends upon how well one can diagnose and upon the effectiveness of the resulting prescriptions.

PROBLEMS WITH CMI

Dr. Frank Baker of the University of Wisconsin Laboratory of Experimental Design, in a paper entitled "Computer Based Instructional

Management Systems: A First Look," cautions us against accepting CMI without questioning the premises it rests on, or rather, without first establishing these premises. Prescriptive procedures in most existing CMI systems generally consist of table look-up schemes in which the test score distribution is divided into several score intervals and remedial actions such as seat work materials, review sessions, etc., are assigned a priori to each score interval. The obtained test score is compared to the distributions and where it falls determines what task or tasks are prescribed for the pupil. The computer merely produces an identification number for a folder in a materials file or for a particular chapter in a text book. In most cases, existing CMI systems prescribe conventional instructional materials, but there does not appear to be sufficient evidence as to the degree of individualization actually afforded by such materials.

Present diagnostic and prescriptive procedures are rudimentary in that they rely primarily on judgments of the relation of test scores to instructional procedures and materials. Much work of both a theoretical and applied nature is needed to put these procedures on a much firmer basis in both CAI and AMI systems.

POTENTIAL FOR EDUCATIONAL RESEARCH

Despite the problems, the capability of the CMI system to provide information at a level of detail heretofore essentially unavailable adds a new dimension to research. All teaching involves decisions about how instruction should proceed. Using a CMI system necessitates making these

decisions consciously and continuously, thinking them out thoroughly, and then testing them. The powerful data collection and reduction capabilities of the computer offer immense possibilities for studying and controlling the variables of learning which should lead to the development of thoroughly tested and validated instructional materials and teaching strategies, and ultimately, to a theory of instruction itself. Patterns of educational experiences of each pupil can be extracted, studied, and related to the management techniques employed by the teacher. Thus, it is possible to study the dynamics of instruction as they relate to individuals and have these studies based on a wealth of detailed information. The ability to perform such studies will not be achieved easily as new techniques need to be developed to facilitate meaningful interpretation of extensive detailed information for a single pupil. But, if we utilize the computer and CMI optimally, it will not only help us teach--it will help us learn.

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